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AGROCLIMATIC REGIONS IN THE PHILIPPINES

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1.0 Agriculture and the Philippine Economy

Agriculture occupies a central role in the economic growth and development of the Philippines, since primary agricultural commodities comprise about two-fifths of the national output. The Philippine economy exemplifies the potential impact of agriculture to the overall development of a country. The limited off-farm employment opportunities in the rural areas and the generally capital-intensive bias in the growth of the industrial sector emphasize the need for agricultural development. For a long time to come, the agricultural sector will be looked upon as an important source of employment and livelihood for the rural populace.

Failures in agriculture can seriously impede programs for a total development of an economy. An analysis of sectoral growth in the Philippines underscores the significance of agriculture to the whole economy. Advances in agriculture influence industrial as well as total economic performance. During the years 1950 through 1966 a limited expansion of the agricultural sector and a consequent reliance on manufacturing based on imported rather than on indigenous raw materials did not provide a conducive atmosphere for

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an accelerated improvement of the Philippine economy. It was generally agreed that more growth could have been realized had the agricultural sector expanded at a faster rate (G. P. Sicat, 1972).

Problems with food supply have great economic and political repercussions. A high rate of population growth brings undesirable effects whenever supply fails to keep adequate pace with growing demand. In particular, frequent food crises create instability and further compound the effects of inflation on the welfare of people.

2.0 Agricultural Development Experience and Its Implications

Experiences during the past decades revealed a limited potency of development policies founded on diffusion models. "Efforts to achieve agricultural development by the direct transfer of foreign technology have been largely unsuccessful. Modern agricultural technology has evolved largely in the developed countries of the temperate zone and is primarily adapted to their ecology and factor endowments. Inadequate recognition of the location-specific character of agricultural technology was a major reason for the lack of effectiveness of much of the technical assistance effort of national and international agencies during the 1950's and 1960's" (Y. Hayami and V. W. Ruttan, 1971, pp.169-170).

There have been only limited successes in modernizing the traditional agriculture of poor countries and a failure to sustain rapid agricultural advances over a sufficiently long period of time. Take the case of the new rice varieties in South and Southeast Asia. Dissimilarities in the growing environment contribute to an uneven distribution of the new technology among regions. The rates of adoption of supporting technologies like irrigation and fertilizer vary from one area to another (T. Anden and R. Barker, 1974).

In large parts of Asia, the new rice remains unsuitable because of the absence of the key requirements for adoption, like good water control and other factors (D. E. Welsch and E. W. Sprague, 1969; R. Barker, 1969). The gains from the adoption of the new seeds and other inputs are substantial; however, "only in a very narrow geographical environment has the growth in yield been so rapid as to establish a higher production trend" (R. Barker, 1973, p. 2).

Differences occur among areas within a country as they do among countries. Agricultural needs vary from region to region due to dissimilarities in resource endowments and constraints to agricultural change. To be effective, the strategy for development should be compatible with resource endowments and agroclimatic characteristics. For example the rapid growth and progressive structure of Taiwan's agriculture has been based upon the development and rapid adoption of effective technologies. The successful modernization of its agriculture is a product of unified planning, structuring agricultural research, and adaptation of basic research results to particular conditions and needs of well-defined agricultural regions (J. W. Brewster, 1967; M. E. Abel and K. W. Easter, 1971).

These development experiences illustrate some lessons for understanding agricultural change:

(1) Identification of regional differences is vital to sharper definition and analysis of the problems of agricultural development. It leads to the formulation of better policy instruments that are consistent with regional needs and constraints.

(2) The process of agricultural progress is less rigorously understood and strategies may become ineffective when conceived at a highly aggregative level as, for example, on a national basis. The weakness becomes acute as

the heterogeneity of aggregated areas increases.

3.0 Objectives

This study focuses, therefore, on agroclimatic characteristics in view of their fundamental influence on the structure of regional agricultural productivity. We seek to identify, measure, and take account of relevant agroclimatic characteristics in order to better understand the problems of increasing agricultural output. To move towards accomplishing this final goal, we propose to delineate agroclimatic regions in the Philippines and to characterize the regional profiles. This paper primarily presents the empirical results of the necessary first step of classifying the provinces into distinct agricultural regions. The study conceives a "region" as a unit made up of provinces, which are not necessarily contiguous but are internally homogeneous with respect to a given set of agroclimatic variables.

We shall also address the question of how the regional groupings relate to rice productivity. The choice of rice as a subject of analysis is influenced by its importance as a major food crop, by the continued government emphasis on the rice sector, and also by data availability. However, we see no difficulty in extending a similar analysis to other crops.

4.0 Organization of the Paper

In the following section we sketch the general methodology because undoubtedly the full significance of the agroclimatic classification becomes clear in the context of the entire model. Section 6.0 reviews the literature. Section 7.0 discusses the variables used and the data adjustments made. We limit the present empirical estimation of the general model in section 5.0 to the delineation of homogeneous regions and to the mapping out of rice yields of the agroclimatic regions. Appendix A contains the complete details of the discriminant and regression models employed in the estimation. The results are presented and discussed in sections 8.0 to 12.0. Appendix B presents the coefficients of the discriminant functions used in the agro-climatic classification.

5.0 Theoretical Construct

Rice production varies according to the response to, as well as the intensity of, farm inputs. In figure 1 below R_1 and R_2 are two production regimes. The difference between the response curves decomposes into technological and environmental factors.[1/] The curves conceivably describe either the performance of biological technology in two distinct environments or of two technologies in the same environment.

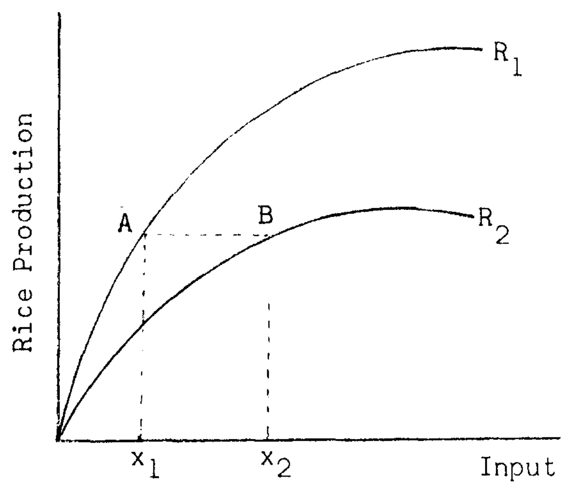

Figure 1. Sources of productivity variations

[1/] In this section we shall equate "technology" to biological technology or to two broad types of rice, namely: traditional and modern varieties. The modern varieties are the short, stiff-strawed, early maturing, photo-period-insensitive rice varieties.

The environmental factors determine to a significant degree the relative suitability of rice technologies to location specific conditions like soil and rainfall. Thus, the response parameters in different environments would reflect, if present, the differential adaptability of a given technology. If the crop response is invariant, then production depends only on the intensity of input use and, by implication, of the physical environment and the sociological and economic variables which affect decisions about input levels.

The graphical relations in figure 1 provide a starting point to formalize a model for analyzing productivity. The model must incorporate environmental variables, technology, and farm inputs. Thus,

$$Y = f(X_1, X_2, \ldots X_K, T, D_1, D_2, \ldots D_P, \varepsilon) \tag{1}$$

where:

Y is rice production

X_i is an input

T is a technology variable

D_i is an environmental variable

ε is a random error term.

The production relations in (1) sort out the various responses of a technology in changing environments, as well as the technological differences.

Some conceptual and practical issues stand in the way of a direct estimation of (1). While the X's and T present no special problems, there are virtually no precedents to help define the environmental variables. We do not really know them to begin with. Thus, to account for them means, first, to identify the relevant ones and, then, to develop measures to be able to include them in the production function. It is necessary to characterize every observation with respect to important environmental factors.

The D variables in (1) are essentially external factors. They influence rice production but are usually beyond the individual control of producing units. On theoretical grounds, it seems reasonable to consider agroclimatic characteristics to represent the D variables. These include weather, soil, infrastructures, and the general characteristics of the labor and land resources. They are reported at best only at a provincial level but the number of provinces is small relative to the number of variables. Without time-series data, the few degrees of freedom implies large standard errors.[2/] Also, there are strong reasons to anticipate very high collinearity, especially among the agroclimatic variables. The desirable properties of estimators remain but the standard errors of estimate increase further and make the test of individual coefficients unreliable in judging the importance of each variable.[3/]

To establish the relevance of agroclimatic variables, as well as to improve the reliability of estimates, requires more information than is available at the provincial level. The data base can be expanded cross-sectionally for farm inputs and partially for agroclimatic variables. For some agroclimatic variables, e.g., weather variables, farm level measurements need tremendous amounts of resources but at the same time the exclusion of such variables certainly guarantees biases in the estimation. We can not

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[2/] Apart from complications due to possible autocorrelation, the biggest problem is the nonexistence of time-series data for X and for most agroclimatic variables.

[3/] Multicollinearity poses no problem to the estimates of combined effects of collinear variables. Individual coefficients possibly can be separated by a mixed estimation; however, *a priori* restrictions need to be placed on some coefficients. Unfortunately, no such outside information is available.

estimate (1) for provincial units because of insufficient observations and the unavailability of input information. Neither is an estimate of (1) possible from purely survey information. The implication is quite clear. Blend available information and estimate (1) at the farm level using provincial information for agroclimatic variables.

We employ the technique of discriminant analysis to classify provinces into distinct agroclimatic regions. Appendix A contains the discriminant model. Readers interested in a detailed theoretical exposition of the technique may refer to Appendix A. The ability to characterize homogeneous groups and to distinguish between them insures that observations can be drawn from provinces with contrasting agroclimatic characteristics. Consequently, the influence of agroclimatic variables on the regional variations in productivity becomes operationally quantifiable. Further, farm-level observations can be standardized with respect to agroclimatic characteristics. It is possible to incorporate or hold them constant when evaluating alternative technologies and it also helps to minimize the biases in the estimates of productivity coefficients for farm inputs. In short, the distribution of provinces in the agroclimatic regions permits us to develop measures for the D variables when estimating (1).

6.0 Review of Literature

The concept involved in defining homogeneous regions is not a new one. Regional studies in the past invaribly involved schemes of defining regions according to kinds of homogeneity criterions. A region has always been conceived as a grouping of small spatial units homogeneous with respect to geophysical characteristics, or as having political boundaries such as being under the same administrative jurisdiction of some government machinery, or as being functionally dependent upon the same commercial nucleus or urban center for trade or other economic activities (J. R. Meyer, 1967). The choice of a classification scheme is governed by the objectives of the study and the data situation. The choice will depend partly on how heavily one weighs the relative advantages of using a method that can utilize existing published data or of adopting a new method of classification even though it requires collecting new data. The same way of delimiting regions may not be appropriate where the purpose of agricultural planning differs (A. T. Mosher, 1973).

There are several approaches to regionalization. In the Philippines, development areas have been delimited along administrative lines based on contiguous political subdivisions.[4/] The areas may not coincide with a grouping according to variables relevant to agricultural productivity. But regionalization by political boundaries may have other goals, namely, cultivating leadership at subnational levels and administrative convenience in carrying out policy decisions. After all, the stream of benefits inherent in a good program flows out mainly through an effective implementation by established political institutions.[5/]

Type-of-farming area is another approach in delineating regions for agricultural planning and management (K. W. Easter, 1972; K. Kanungo and

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[4/] Various legislations created 17 regional development entities from 1961 through 1966. Seven are on operating status (J. M. Lawas, 1973).

[5/] This is an empirical consideration which does not interfere with the theoretical framework. A regionalization scheme can cross administrative boundaries as they bear no consequence in the analysis of productivity problems, except in determining the size of the primary unit of observation for which statistics are available.

J. S. Sarma, 1973). This method serves to bring out regional disparities in productivity within crop zones and to identify regions with common production problems. When programs are nationally directed and are commodity oriented, the type-of-farming criterion is appropriate for regionalization.[6/]

Alternatively, agricultural regions can be defined by using agroclimatic zoning (M. E. Abel and K. W. Easter, 1971; K. W. Easter, 1972). The rationale behind the technique is that agricultural regions and their needs, rather than farm commodities, form the basic component of regional planning. The Abel-Easter model appears consistent with the premise that increasing agricultural capacity, together with maximizing output from existing capacity, is a viable long-term strategy for agricultural growth. It is also consistent with the recognition that a dynamic modern agriculture is achieved locality by locality and district by district (A. T. Mosher, 1973).

To the extent that climatic and environmental influences set a geographical pattern of production, the type-of-farming approach overlaps the agroclimatic zoning method. However, the former is inadequate for separating regional productivity differences which are attributable to reproducible factors. The latter is a more integrated mechanism as it extends into the identification of specific constraints to productivity and underscores the significance of dealing with the restraints in a sequential manner. But the principle remains to be translated into an operational methodology.

Finally, there is a regionalization based on the degree of immediacy of the future growth potential of areas. Growth potential of an area is

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[6/] For example, the approach is useful in the national coordination of rice and corn programs in terms of locating areas where yield and other problems exist.

gauged according to the presence or absence of certain factors of agricultural development (A. T. Mosher, 1971). This method operates essentially on the same principle inherent in the Abel-Easter approach insofar as it relates to the issue of capacity building in agriculture and to the temporal dimensions of development planning.

7.0 Data and Variables

A province is the unit of analysis used here. It is that political subdivision next to the national level. Under the circumstances, a province emerges as the best operational compromise. We agree that a province may still be such a large unit that it impinges on the homogeneity of delineated regions. On one hand, villages and towns within a province might possess sufficient variability to cast some doubts on the representativeness of provincial measures. Ideally, the basic analytical unit should be smaller, preferably a municipality if not a village. On the other hand, the information constraint is quite binding. At best, statistics usually are published for provinces but not for smaller units. We are aware that to summarize characteristics into a provincial value often means less information and less homogeneity within agricultural regions than we desire to achieve. But the alternative source of information is quite costly. To generate one's data for villages or municipalities is not feasible because it is costly. At the same time, it invariably restricts the geographical scope and certainly raises the issue of where to start.

To delineate regions, six sets of criteria are defined from a natural grouping of several variables described below. The year and the original source of the basic data are in parentheses.

A. Land Resource Characteristics

1. Effective cropping index (1960, Bureau of Census and Statistics) is a measure of the annual intensity of rice land use and is a ratio of total rice planted to absolute rice hectarage. A higher ratio indicates a greater degree of double cropping.

2. Percent rice area (1960, Bureau of Census and Statistics) shows the relative importance of rice to a province. It is measured here as the proportion of absolute rice hectarage to total arable land planted to temporary crops.

3. Percent rice area irrigated (1960, Bureau of Census and Statistics) reflects the extent of effective rice area under irrigation. It is constructed to indicate land quality of rice areas and, to some extent, the quality of irrigation facilities. If the facilities are serviceable for a longer period in a year, more rice land is irrigated given the degree of double cropping.

4. Percent land graded over 30° (Bureau of Soils) is intended as a proxy for provincial land topography; it is a ratio of land area which slopes more than 30° to total area of the province.

5. Percent idle land (1960, Bureau of Census and Statistics) represents idle but arable lands. It indicates the relative availability of the land resource for expansion.

B. Agricultural Infrastructure

1. Loans to agriculture (1970-71, Development Bank of the Philippines, Philippine National Bank, Central Bank of the Philippines) are from agencies which extend financial assistance to agriculture like the Philippine National Bank, the Development Bank of the Philippines, the Agricultural Credit Administration, and the rural banks. Loans to agriculture include only institutional loans. It is the total of the loans extended by the four

agencies deflated by arable hectarage to correct for relative size of the province.

2. Road density (1971, Bureau of Public Highways) refers to length of roads for every 1,000 arable hectares. It excludes city roads.

3. Percent earth roads (1971, Bureau of Public Highways), a supplement to density measure, indicates road quality. A higher value means less weather-resistant roads or more unusable roads during seasons of inclement weather.

4. Ratio of 1972 to 1960 irrigated area (National Irrigation Administration, Agricultural Productivity Commission, and Presidential Arm on Community Development) refers mainly to the rice area serviced by pump and gravity irrigation systems. With public sector projects for improving irrigation infrastructures usually there are other agricultural programs available, such as credit, seed distribution, and extension. This ratio can be regarded as a simplistic proxy for relative change in government interest in each province over time.

5. Rice mill capacity (1971, Rice and Corn Board) is the total provincial daily milling capacity for every 10,000 rice hectares.

6. Warehouse capacity (1971, Rice and Corn Board) is the total provincial storage capability for every hectare of rice.

C. Population Characteristics

1. Percent self-employed (1970, Bureau of Census and Statistics) is a proportion of the economically active population, ten-years old and over, who do not work for others, private or government.

2. Percent family labor (1970, Bureau of Census and Statistics) is a proportion of the economically active population, ten-years old and over, who work for the family and are not paid cash wages.

3. Labor force in agriculture (1970, Bureau of Census and Statistics) is the percentage of economically active population, ten-years old and over, who depend on the agricultural sector for employment or livelihood.

4. Percent rural population (1970, Bureau of Census and Statistics) includes people who live outside the cities. Presumably, the urban-rural population mix affects the pattern of agricultural activities, demand for farm commodities, off-farm employment opportunities, supply of labor to farms, and availability of purchased inputs.

5. Population density (1970, Bureau of Census and Statistics) is a measure of population pressure on land resources. Often, it is associated with economic problems and is an important dimension in the choice of technology for increasing agricultural output.

6. Literacy rate (1970, Bureau of Census and Statistics) is an index of educational attainment of the population and conceivably indicates the general quality of the labor resource. Quite possibly, literacy rate may affect the effectiveness of, say, government extension programs in agriculture.

7. Annual budget surplus (1965, Bureau of Census and Statistics) represents the average excess of earnings over expenses for the basic needs of a family. To some extent, it reflects the capability to self-finance other expenditures. For example, to a farm family the budget surplus is potentially available for financing farm operations.

8. Income tax per capita (1971, Economic Atlas of the Philippines), a major source of revenue to finance public expenditures, indicates the nature of employment activities and the general economic status of the people. A higher per capita tax income implies more cash employment or greater monetary income.

D. Soil

1. Soil type (Bureau of Soils) refers to the relative soil composition and includes clay, clay loam, sand, sandy loam, silt loam, loam, and undifferentiated. This list is not exhaustive. Soil types not common to all provinces are excluded.

E. Rainfall

1. Rainfall (1950-70, Weather Bureau) is a major source of irrigation water. It is one of the factors crucial to agriculture. Another is solar radiation. Unfortunately, weather stations do not monitor solar radiation and provincial data are not available. Rainfall refers to the monthly climatic pattern or normal values over a period of years. Temperature, humidity, wind velocity, and pressure also affect plant growth. But these climatic factors exhibit practically no geographic variations in the Philippines.

F. Rice Productivity

1. Rice productivity is measured as yield per unit of land. Rice production statistics are published at regional levels by the Bureau of Agricultural Economics. As a rule, this government agency releases no provincial data to the general public. And data available through other sources are considered unofficial. From reports of field technicians to the Central Office of the National Food and Agriculture Council, we compiled our provincial estimates of rice yield. To validate our data, we used the provincial rice yields published in the Economic Atlas of the Philippines (1972) which were based, as cited, on official statistics. Its correlation with our 1971 estimates is high ($r = 0.8825$ for a sample size of 38). On this rests our confidence in using our yield estimates for the years 1970 through 1974.

8.0 Estimating the Group Parameters

The model for discriminant analysis is discussed in detail in Appendix A. The discrimination model is basically a series of (g-1) independent mappings from a p into a one dimensional space when p, the number of classification criteria, is greater than g, the number of groups (W. W. Cooley and P. R. Lohnes, 1962). Suppose two groups are to be distinguished based on attributes X and Y. Let each ellipse in figure 2 include a specified percentage of the members from each group. Line D represents a discriminant function and line C is a decision rule. Its intersection with line D gives a criterion E. Observations with discriminant scores to the left of E are allocated to group A and the rest, to group B.

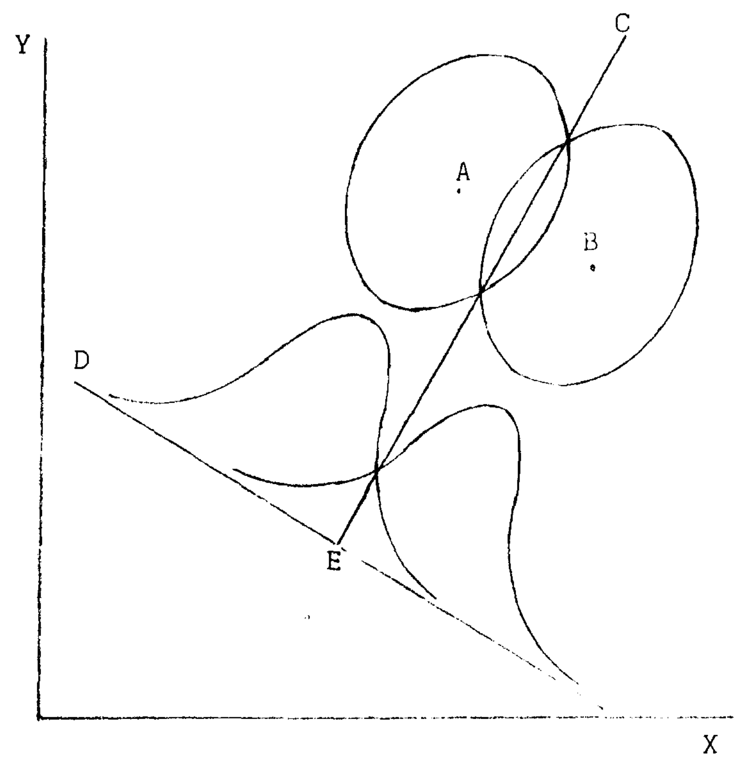

Figure 2. Geometry of discriminant analysis

The model for discriminant analysis presumes prior knowledge of either group parameters or sample estimates of group parameters. Classifying new observations becomes a simple task if parameters are known. In terms of figure 2, centroids A and B together with the dispersion around them must be known to enable allocation of additional points to one of the groups. Otherwise, to estimate parameters requires knowledge of group membership beforehand, at least for a subset of observations. Samples for every group must have been identified to estimate group centroid and dispersion. But had we had prior information, discriminant analysis hardly would have been necessary. We already would have known how provinces group.

At the start, no parameters are known nor have we an established grouping. Our observations are practically all new. And there being no discriminant functions for mapping the points, we face two fundamental questions. How does one know the number of distinct groups? What belongs in which group? Before presenting our results, we will first discuss these questions.

Somewhere between one and the total number of provinces lies the appropriate number of groups. One extreme is to treat individual provinces as separate groups. This leads to the maximum homogeneity possible in each group. Usually not every province is justifiably large or different enough for program purposes to attract individualized attention. A contrast is to classify all provinces into one category. At this stage, generalization is at a maximum but significant details are lost. Group homogeneity becomes dubious. And such a simplistic approach suffers from the dangers of over-aggregation. Both extremes seem quite impractical; however, they serve to illustrate aptly some considerations necessary in choosing the number of groups for our purposes.

There exists a trade-off between internal homogeneity and the number of groups. In the process of grouping, generality can only be gained at the cost of some details. As the members per class increase the grouping diminishes. So does homogeneity. Homogeneity is important but it can not be made absolute. Bear in mind that in the ultimate analysis our end product aims to cater to the needs of agricultural planning. Thus, for operational utility, we also seek intergroup distinctiveness as well as manageability in the number of groups. Preferably too, the aggregate group size should be relevant enough for policymaking.

To categorize productivity into 3 to 5 regimes is a common practice. For us, the range presents a natural choice with respect to the number of groups. We explain our final decision to settle upon a 4-group model after a discussion of the discrimination procedure. It is suffice to say at this point that a 4-group model is a subjective although not an arbitrary choice.

Next comes the question of estimating group parameters or corollarily how provinces, or some of them, group. The procedure is an iterative one. We relied on 1971 rice yields to define class intervals and to initially allocate the provinces. The procedure results in a grouping for which discriminant functions were computed using all the yearly rice productivity data from 1970 to 1974. For each province there are posterior probabilities of belonging to every group. For some cases, the posterior probability of having come from the group in which they are initially subjectively classified turns out to be highest. For others, that is not the case. Based on these posterior probabilities, we reallocated the observations and repeated the cycle of computations. The iterative process terminated when each province recorded the highest posterior probability for the group to which it is assigned.

Of the six sets of classification variables, only in the case of productivity did we work with all 3-, 4-, and 5-group discriminant models. To examine how well groups separate under the three options, we resorted to a plot of the first two canonical variates associated with the set of productivity criteria. The procedure is similar to the process of employing a preliminary scatter diagram to choose, for example, a functional form. A better group separation, as indicated in the plot, was the basis for selecting a 4-group model. The final result of a 4-group productivity classification served as a basis to initiate the discriminant analysis for other sets of criteria. For land, infrastructure, population, soil, and rainfall variables, the initial distribution of the provinces is identical to the memberships in the different rice productivity groups. As before, iterations were made whenever necessary. We report the final results in the following pages.

9.0 Agroclimatic Regions

9.1 Rice productivity. In general, there is no definite yield hierarchy among the groups. No single group consistently dominates. Every group records the highest yield during one year but lags behind during the others (table 1). But the provinces in each group exhibit a striking internal similarity in the patterns of rice yields formed over the years (tables 3 and 4). Considerable improvements characterize yield changes in group A. The 1974 average rice yield is almost double that in 1970. Group C had relatively stable yields. In contrast, groups B and D follow up and down patterns. Nevertheless, group differences in yield patterns appear to be significant (table 2). The distinctiveness between groups which are internally homogeneous has significant implications for agricultural planning. The nature of yield changes common to a number of provinces in every group is at least indicative of factors which influence rice productivity that are specific to an agricultural region. The evidence reinforces the validity of focusing on regional needs in agricultural planning.

9.2 Land resource characteristics. All four groups show statistically significant differences with respect to land resource variables (table 6). Let us take groups B and D. Cropping intensity and land idleness are higher but the percent of rice land is lower in group B than in group D (table 5).[7/] Such group characteristics may be used to explore alternative strategies for increasing rice output and also to identify the program areas. Land is the single most important input to agriculture. But as the provinces exhaust the idle arable lands, cultivation intensity increasingly becomes a source of output growth. Where the intensity of cultivation has reached its limit, additional rice crop must come through land expansion. As much of the idle lands as possible must be brought into cultivation. In some provinces, particularly those in group C, both methods are feasible.

One way to augment the land resource is to develop technologies and strategies to relieve the constraints to increasing effective land use. Land augmentation may be in the form of a better yielding second-crop rice variety, soil management practices, dependable irrigation, credit, and supply of purchased inputs. To undertake irrigation improvements to allow greater cropping intensity of existing hectarage probably suits group D provinces better than the rest, given the low intensity index and percent

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[7/] We must caution the readers that, although our land resource data are the latest available figures, they might be out of date. The results, therefore, are to be taken in the context of illustrative, rather than contemporary significance.

Table 1.- Average rice yields of provinces in different productivity groups, 1970-1974

	GROUP AVERAGE			
	A	B	C	D
	(cavans* per hectare)			
1974	77.56	64.40	76.11	70.27
1973	59.33	69.80	66.00	61.54
1972	68.22	64.20	66.56	63.54
1971	50.22	47.40	58.22	56.18
1970	39.00	51.60	59.33	66.45

*A cavan is a volume measure equivalent to 44 kilograms of rough rice.

Table 2.- Matrix of F statistics for the hypothesis of no difference between a pair of vectors of group means for the yearly rice yields

	Group A	Group B	Group C
Group B	11.79*		
Group C	30.02*	3.54	
Group D	65.12*	13.40*	5.84*

*Significant at 1% level; the critical F value at 5 and 26 degrees of freedom is 3.818 at 1% level and is 2.587 at 5% level.

Table 3.- Distribution of provinces among the productivity groups

Group A	Group B	Group C	Group D
1. Antique	1. Davao	1. Batangas	1. Aklan
2. Bohol	2. Cagayan	2. Camarines Norte	2. Albay
3. Cotabato	3. Camarines Sur	3. Cavite	3. Bataan
4. Ilocos Norte	4. Ilocos Sur	4. La Union	4. Bukidnon
5. Negros Oriental	5. Occidental Mindoro	5. Leyte	5. Bulacan
6. Oriental Mindoro		6. Misamis Oriental	6. Isabela
7. Surigao		7. Pampanga	7. Laguna
8. Zamboanga Norte		8. Pangasinan	8. Misamis Occidental
9. Zamboanga Sur		9. Quezon	9. Nueva Ecija
			10. Nueva Viscaya
			11. Tarlac

Table 4.- Individual profile of provinces in relation to the productivity groups

Case # a/	Square of Distance (D^2) from and Posterior Probability (p) for							
	Group A		Group B		Group C		Group D	
	D^2	p	D^2	p	D^2	p	D^2	p
Group A								
1	1.94	1.00	18.90	*	31.20	*	63.95	*
2	5.25	.98	12.63	.02	19.81	*	46.24	*
3	5.92	1.00	25.52	*	35.32	*	72.06	*
4	3.34	1.00	25.64	*	45.94	*	83.23	*
5	1.51	1.00	21.36	*	38.63	*	73.87	*
6	10.31	.95	16.40	.05	35.27	*	71.34	*
7	10.77	1.00	50.49	*	82.58	*	133.75	*
8	1.82	1.00	22.38	*	37.02	*	71.71	*
9	3.76	1.00	41.85	*	65.26	*	111.59	*
Group B								
1	17.42	*	3.49	.93	8.67	.07	29.06	*
2	44.72	*	6.36	.95	12.48	.04	19.89	*
3	23.61	*	3.54	1.00	14.61	*	32.67	*
4	13.40	*	2.67	.96	9.03	.04	29.16	*
5	29.13	*	6.43	.82	9.42	.18	24.13	*
Group C								
1	32.49	*	6.96	.14	3.36	.86	15.82	*
2	33.32	*	3.30	.27	1.33	.72	10.15	.01
3	36.18	*	4.45	.41	3.77	.58	13.41	.01
4	48.11	*	12.59	*	1.61	.90	6.16	.10
5	34.72	*	9.65	.04	3.48	.95	13.02	.01
6	57.09	*	24.62	*	11.84	.86	15.57	.14
7	51.37	*	10.45	.02	2.75	.82	6.00	.16
8	52.92	*	16.13	*	3.58	.55	3.98	.45
9	33.68	*	2.44	.41	1.75	.58	10.61	.01
Group D								
1	103.59	*	35.27	*	20.90	*	6.61	1.00
2	72.51	*	22.17	*	9.85	.03	3.02	.97
3	68.49	*	17.13	*	5.21	.11	1.01	.89
4	105.29	*	37.23	*	19.87	.01	10.75	.99
5	69.32	*	22.34	*	6.47	.09	1.93	.91

(continued)

Table 4 (continued)

Case # a/	Square of Distance (D^2) from and Posterior Probability (p) for							
	Group A		Group B		Group C		Group D	
	D^2	p	D^2	p	D^2	p	D^2	p
Group D								
6	91.48	*	31.08	*	12.79	*	1.48	1.00
7	67.03	*	21.60	*	5.54	.13	1.80	.87
8	78.03	*	31.38	*	10.43	.06	4.99	.94
9	89.86	*	33.22	*	15.74	.01	6.99	.99
10	76.99	*	25.38	*	11.95	.04	5.59	.96
11	61.74	*	19.95	*	5.52	.46	5.23	.54

*The posterior probability is nil or zero.

a/ The case number corresponds to the province number in the table immediately preceding.

Table 5.- Characteristics of provincial groupings based on land resource variables

	GROUP AVERAGE A	B	C	D
1. Effective cropping index for rice (percent)	134.00	134.77	111.56	109.62
2. Percent rice area	55.70	41.12	30.85	72.17
3. Percent of rice area irrigated	16.04	33.29	24.97	37.49
4. Percent land graded over 30 degrees	33.60	30.60	39.73	49.50
5. Percent idle land	22.24	25.04	27.40	14.31

Table 6.- Matrix of F statistics for the hypothesis of no difference between a pair of vectors of group means for land resource variables

	Group A	Group B	Group C
Group B	10.82*		
Group C	51.72*	30.02*	
Group D	24.24*	11.16*	16.81*

*Significant at 1% level; the critical F value at 5 and 39 degrees of freedom is less than 3.699 at 1% level.

Table 7.- Distribution of provinces among the different land resource groups

Group A	Group B	Group C	Group D
1. Bohol	1. Agusan	1. Bukidnon	1. Abra
2. Cagayan	2. Albay	2. Cavite	2. Aklan
3. Capiz	3. Bataan	3. Cebu	3. Antique
4. Iloilo	4. Batangas	4. Davao	4. Cotabato
5. Marinduque	5. Bulacan	5. Ilocos Norte	5. Ilocos Sur
	6. Camarines Norte	6. Laguna	6. Isabela
	7. Camarines Sur	7. Lanao	7. La Union
	8. Catanduanes	8. Masbate	8. Nueva Ecija
	9. Leyte	9. Misamis Oriental	9. Nueva Viscaya
	10. Misamis Occidental	10. Negros Occidental	10. Pampanga
	11. Quezon	11. Negros Oriental	11. Pangasinan
	12. Samar	12. Occidental Mindoro	12. Tarlac
	13. Surigao	13. Oriental Mindoro	13. Zambales
		14. Palawan	
		15. Zamboanga Norte	
		16. Zamboanga Sur	

Table 8.- Individual profile of provinces in relation to the land resource groups

Case # a/	Square of Distance (D^2) from and Posterior Probability (p) for							
	Group A		Group B		Group C		Group D	
	D^2	p	D^2	p	D^2	p	D^2	p
Group A								
1	7.15	1.00	23.33	*	90.42	*	55.80	*
2	5.56	1.00	35.00	*	108.04	*	62.44	*
3	1.98	1.00	18.41	*	71.96	*	33.08	*
4	4.01	.96	10.13	.04	52.94	*	19.50	*
5	0.82	1.00	15.25	*	70.42	*	33.77	*
Group B								
1	33.47	*	4.90	.86	10.46	.05	9.50	.09
2	20.65	*	3.66	1.00	33.44	*	16.52	*
3	13.44	.02	5.68	.96	41.16	*	12.91	.02
4	19.12	*	6.82	.98	28.02	*	14.99	.02
5	15.66	.01	7.21	.50	35.23	*	7.23	.49
6	20.00	*	8.54	1.00	45.20	*	28.81	*
7	19.88	*	1.71	.94	21.05	*	7.08	.06
8	14.06	.02	6.33	.98	42.33	*	25.32	*
9	12.09	.01	1.41	.99	32.52	*	15.64	*
10	38.69	*	4.94	.80	10.41	.05	8.23	.15
11	9.88	.08	5.04	.92	39.99	*	15.71	*
12	39.05	*	9.26	.91	14.23	.08	17.95	.01
13	31.19	*	6.86	.98	18.36	*	15.50	.02
Group C								
1	85.70	*	30.80	*	1.54	1.00	19.64	*
2	85.44	*	29.61	*	4.20	1.00	18.14	*
3	86.92	*	30.17	*	8.55	1.00	27.53	*
4	80.16	*	27.94	*	1.60	1.00	17.40	*
5	114.94	*	52.48	*	15.52	.96	21.95	.04
6	86.60	*	29.26	*	8.75	1.00	22.56	*
7	63.89	*	19.91	*	2.31	.88	6.39	.11
8	59.32	*	16.74	.01	6.40	.99	16.68	*
9	87.28	*	29.30	*	2.36	1.00	21.46	*
10	61.79	*	18.23	*	3.01	.99	13.06	.01
11	85.08	*	29.94	*	2.16	1.00	19.48	*
12	96.13	*	38.02	*	2.92	1.00	20.51	*
13	67.70	*	21.16	*	1.09	.99	9.56	.01

(continued)

Table 8 (continued)

Case # [a]	Square of Distance (D^2) from and Posterior Probability (p) for							
	Group A		Group B		Group C		Group D	
	D^2	p	D^2	p	D^2	p	D^2	p
Group C								
14	97.31	*	41.22	*	14.19	1.00	30.27	*
15	60.48	*	18.58	*	3.21	.98	11.14	.02
16	58.95	*	15.96	*	2.26	.98	10.59	.02

*The posterior probability is nil or zero.

[a] The case number corresponds to the province number in the table immediately preceding.

idle land, as well as the high proportion of land graded over 30 degrees. For other areas, the irrigation facilities may be developed to bring currently idle lands into cultivation. Provinces in group B would seem to be the areas where such programs could be undertaken. Of course, developing the irrigation to expand the use of existing hectarage or to open up idle lands to cultivation are not necessarily mutually exclusive and may be combined for maximum impact.

9.3 Agricultural infrastructure. The differences between groups of internally alike provinces continue to stand out and, like before, these differences are statistically significant (table 10). The loans to the agricultural sector of provinces in group B exceed by several fold those made to other provinces (table 9). In all of group B provinces, sugarcane is a major cash crop and it is highly likely that the loans to the sugarcane sector would constitute a very high proportion of agricultural credit. The financial institutions tend to participate more actively in the agricultural sector of sugarcane provinces (table 11). This fact probably surprises nobody because of the capital requirements of the sugarcane sector, the degree of commercialization, and its economic importance to the foreign trade of the country.

What is surprising is to find the highest concentration of milling and warehousing capacities in group C provinces (table 9). With the possible exception of Cotabato, these provinces are not the major rice areas. In contrast, group D (table 11) with the traditional rice growing provinces like Bulacan, Nueva Ecija, Pangasinan, and Tarlac record the lowest average milling and warehousing capacities. It is indeed possible that the facilities are convertible to corn milling and warehousing and that corn

Table 9.- Characteristics of provincial groupings based on agricultural infrastructures

	GROUP AVERAGE			
	A	B	C	D
1. Loans to agriculture (pesos per arable hectare)	77.73	512.60	42.31	67.06
2. Percent earth road	28.79	22.66	36.85	16.78
3. Ratio of 1972 to 1960 irrigated rice area	2.54	1.83	2.09	1.34
4. Rice milling capacity (cavans per day per 10,000 rice hectares)	42.35	45.64	127.05	28.58
5. Warehouse capacity (cavans/rice hectare)	49.85	43.02	158.51	17.26
6. Road density (kilometers of road per 1,000 arable hectares)	26.71	13.80	10.46	13.42

Table 10.- Matrix of F statistics for the hypothesis of no difference between a pair of vectors of group means for agricultural infrastructures

	Group A	Group B	Group C
Group B	23.34*		
Group C	31.27*	23.10*	
Group D	20.02*	22.10*	8.28*

*Significant at 1% level; the critical F value at 6 and 38 degrees of freedom is less than 3.474 at 1% level.

Table 11.- Distribution of provinces among the groupings based on agricultural infrastructures

Group A	Group B	Group C	Group D
1. Abra	1. Cavite	1. Bukidnon	1. Agusan
2. Bataan	2. Iloilo	2. Camarines Sur	2. Aklan
3. Batangas	3. Laguna	3. Cebu	3. Albay
4. Bohol	4. Negros Occidental	4. Cotabato	4. Antique
5. Ilocos Norte	5. Pampanga	5. Davao	5. Bulacan
6. Ilocos Sur		6. Lanao	6. Cagayan
7. La Union		7. Masbate	7. Camarines Norte
8. Misamis Occidental		8. Negros Oriental	8. Capiz
9. Misamis Oriental		9. Surigao	9. Catanduanes
10. Nueva Viscaya		10. Zamboanga Sur	10. Isabela
11. Occidental Mindoro			11. Leyte
12. Zambales			12. Marinduque
			13. Nueva Ecija
			14. Oriental Mindoro
			15. Palawan
			16. Pangasinan
			17. Quezon
			18. Samar
			19. Tarlac
			20. Zamboanga Norte

Table 12.- Individual profile of provinces in relation to the agricultural infrastructure groups

Case # a/	Square of Distance (D^2) from and Posterior Probability (p) for							
	Group A		Group B		Group C		Group D	
	D^2	p	D^2	p	D^2	p	D^2	p
Group A								
1	10.77	1.00	57.98	*	57.22	*	41.79	*
2	11.23	1.00	26.58	*	58.45	*	29.30	*
3	22.44	.97	54.85	*	39.19	*	29.74	.03
4	6.82	1.00	79.84	*	64.97	*	38.23	*
5	5.34	.93	51.87	*	32.00	*	10.58	.07
6	1.81	1.00	50.37	*	36.98	*	19.75	*
7	3.72	1.00	55.27	*	64.47	*	35.10	*
8	2.95	1.00	43.14	*	39.28	*	19.17	*
9	5.86	.98	39.62	*	24.04	*	13.86	.02
10	2.93	.98	36.58	*	27.97	*	10.92	.02
11	18.69	1.00	91.17	*	80.70	*	49.41	*
12	4.65	1.00	48.71	*	39.10	*	16.85	*
Group B								
1	31.75	*	3.56	1.00	45.91	*	30.96	*
2	37.33	*	8.75	.94	21.22	*	14.26	.06
3	48.09	*	4.18	1.00	66.53	*	51.48	*
4	97.49	*	12.06	1.00	92.99	*	84.54	*
5	44.99	*	6.60	1.00	43.82	*	41.50	*
Group C								
1	38.59	*	50.61	*	0.62	.97	7.74	.03
2	41.78	*	50.14	*	0.99	.97	7.79	.03
3	85.92	*	94.65	*	38.09	1.00	56.12	*
4	44.60	*	51.57	*	4.16	1.00	16.63	*
5	39.53	*	50.88	*	2.31	.93	7.52	.07
6	51.27	*	53.29	*	2.98	.98	11.19	.02
7	41.00	*	51.73	*	2.72	.85	6.22	.15
8	35.98	*	25.59	*	7.76	.94	13.47	.06
9	25.90	*	54.24	*	6.37	.83	9.53	.17
10	53.46	*	56.64	*	2.74	1.00	16.84	*
Group D								
1	30.87	*	46.05	*	4.23	.27	2.26	.73
2	10.04	.02	39.35	*	10.58	.02	2.38	.96
3	11.33	.01	32.90	*	12.43	.01	2.54	.98

(continued)

Table 12 (continued)

Case # a/	Square of Distance (D^2) from and Posterior Probability (p) for							
	Group A		Group B		Group C		Group D	
	D^2	p	D^2	p	D^2	p	D^2	p
Group D								
4	18.92	*	36.85	*	5.31	.18	2.29	.82
5	13.44	.02	23.64	*	23.20	*	5.36	.98
6	29.74	*	50.19	*	5.11	.19	2.17	.81
7	21.16	*	34.94	*	14.43	*	1.58	1.00
8	28.86	*	27.37	*	5.59	.20	2.75	.80
9	16.33	*	50.15	*	17.54	*	2.76	1.00
10	19.13	*	39.63	*	6.62	.06	1.14	.94
11	21.70	*	37.54	*	9.57	.01	.45	.99
12	15.55	*	53.52	*	21.54	*	3.98	1.00
13	20.19	*	42.09	*	16.43	*	3.19	1.00
14	32.77	*	46.59	*	8.44	.14	4.84	.86
15	14.87	*	38.36	*	8.06	.07	2.86	.93
16	18.40	*	31.60	*	11.10	*	.53	1.00
17	17.27	*	31.18	*	15.15	*	2.59	1.00
18	30.72	*	56.23	*	15.51	*	4.18	1.00
19	30.81	*	38.69	*	5.97	.13	2.10	.87
20	17.25	*	50.33	*	8.72	.29	6.91	.71

*The posterior probability is nil or zero.

a/ The case number corresponds to the province number in the table immediately preceding.

hectarage should have been added to the deflator to reflect the real standardized capacities. Otherwise these figures could mean one of two things. Either there is a capacity surplus in group C or a severe shortage in group D. At the very least the figure would indicate a spatial imbalance in the distribution of capacities.

9.4 Population characteristics. Table 13 presents the group summary of the population characteristics of the provinces. Although both self and family employment constitute the major source of jobs for all groups, their total varies. Self employment and family employment together account for percentages ranging from a low of 57 percent of the jobs in group A to a high of 69 percent in group D. These figures underscore the tremendous benefits to the national economy from agricultural progress. In most cases, these jobs are likely to be agricultural. Notice that self and family employment tend to increase with the labor force in agriculture. The exception is group B. But group B has the smallest proportion of rural population. It also ranks highest in income tax per capita. Both suggest the likelihood of relatively more off-the-farm employment.

The differences in the extent of paid employment and in the availability of nonagricultural jobs perhaps correlate well with the discrepancies in the annual budget surplus per family. For example, group B, followed by group A, are highest in annual surplus. The proportion of the labor force in agriculture is lowest in group B while group A has the least proportion of those self and family employed.

There are also noticeable variations among groups with respect to other attributes. Population density varies from an average of 114.63 persons per square kilometer in group D to 181.59 in group A. Literacy rate has a

Table 13.- Characteristics of provincial groupings based on population variables

	GROUP AVERAGE			
	A	B	C	D
1. Percent self employed	35.47	38.60	47.14	43.01
2. Percent rural population	82.76	67.91	79.54	81.02
3. Income tax per capita	8.83	13.07	9.08	8.91
4. Literacy rate	82.15	84.26	86.16	79.94
5. Percent family labor	22.06	19.48	20.60	26.15
6. Percent of labor force in agriculture	56.84	48.78	59.68	63.84
7. Annual budget surplus per family (pesos)	551.00	599.25	396.54	289.00
8. Population density (number of persons per square kilometer)	181.59	177.44	139.90	114.63

Table 14.- Matrix of F statistics for the hypothesis of no difference between a pair of vectors of group means for population variables

	Group A	Group B	Group C
Group B	20.08*		
Group C	18.47*	11.55*	
Group D	6.57*	9.02*	5.58*

*Significant at 1% level; the critical F value at 8 and 36 degrees of freedom is less than 3.173 at 1% level.

Table 15.- Distribution of provinces among the groupings based on population variables

Group A	Group B	Group C	Group D
1. Aklan	1. Bataan	1. Bohol	1. Abra
2. Albay	2. Bulacan	2. Camarines Norte	2. Agusan
3. Cagayan	3. Catanduanes	3. Camarines Sur	3. Antique
4. Capiz	4. Cavite	4. Leyte	4. Batangas
5. Ilocos Sur	5. Cebu	5. Marinduque	5. Bukidnon
6. Isabela	6. Ilocos Norte	6. Masbate	6. Cotabato
7. La Union	7. Laguna	7. Nueva Ecija	7. Davao
8. Negros Occidental	8. Lanao	8. Occidental Mindoro	8. Iloilo
9. Negros Oriental	9. Nueva Viscaya	9. Oriental Mindoro	9. Misamis Occidental
10. Pampanga	10. Palawan	10. Pangasinan	10. Misamis Oriental
11. Tarlac	11. Surigao	11. Quezon	11. Samar
	12. Zambales		12. Zamboanga Norte
			13. Zamboanga Sur

Table 16.- Individual profile of provinces in relation to the groups based on population characteristics

Case # a/	Square of Distance (D^2) from and Posterior Probability (p) for							
	Group A		Group B		Group C		Group D	
	D^2	p	D^2	p	D^2	p	D^2	p
Group A								
1	9.30	1.00	65.02	*	69.73	*	35.85	*
2	7.79	.98	45.47	*	26.04	*	15.30	.02
3	3.66	.90	27.69	*	25.78	*	8.11	.10
4	4.34	1.00	49.76	*	43.97	*	18.45	*
5	5.22	.88	23.16	*	29.94	*	9.28	.12
6	5.54	.99	43.44	*	36.80	*	14.43	.01
7	6.88	.94	34.98	*	28.24	*	12.27	.06
8	15.70	.99	38.93	*	50.77	*	25.52	.01
9	4.68	.99	41.04	*	42.27	*	13.52	.01
10	12.16	1.00	29.34	*	47.87	*	25.66	*
11	10.79	1.00	55.12	*	37.55	*	23.64	*
Group B								
1	45.04	*	19.75	1.00	49.91	*	38.30	*
2	53.89	*	5.43	1.00	35.18	*	31.90	*
3	38.09	*	8.06	.99	20.25	*	17.24	.01
4	53.19	*	8.05	1.00	31.77	*	30.14	*
5	30.38	*	9.39	.99	30.98	*	18.76	.01
6	25.78	*	4.11	.75	15.72	*	6.37	.25
7	38.41	*	12.19	.98	24.30	*	19.78	.02
8	69.41	*	22.56	1.00	37.68	*	37.01	*
9	46.29	*	18.70	1.00	30.75	*	31.14	*
10	32.96	*	10.37	.98	36.97	*	18.50	.02
11	64.73	*	10.47	1.00	23.07	*	31.84	*
12	57.61	*	25.37	1.00	48.63	*	39.14	*
Group C								
1	42.96	*	15.79	.01	6.57	.97	14.14	.02
2	34.63	*	30.14	*	7.32	.99	17.05	.01
3	24.95	*	28.95	*	9.06	.95	14.87	.05
4	28.06	*	19.49	*	3.33	.84	6.72	.16
5	36.47	*	35.25	*	4.32	1.00	15.68	*
6	39.56	*	28.49	*	3.41	1.00	14.07	*
7	27.30	*	17.02	*	2.24	.92	7.21	.08
8	45.37	*	12.69	.03	5.98	.96	15.34	.01
9	53.02	*	33.41	*	3.53	1.00	20.74	*

(continued)

Table 16 (continued)

Case # a/	Square of Distance (D^2) from and Posterior Probability (p) for							
	Group A		Group B		Group C		Group D	
	D^2	p	D^2	p	D^2	p	D^2	p
Group C								
10	22.78	*	16.52	*	4.89	.74	7.04	.26
11	53.11	*	29.09	*	4.65	1.00	20.83	*
Group D								
1	13.01	.01	10.06	.04	17.56	*	3.82	.95
2	20.74	*	6.94	.16	9.16	.06	3.81	.78
3	8.29	.06	17.18	*	12.88	.01	2.90	.93
4	17.73	.01	19.25	*	10.78	.28	8.91	.71
5	8.96	.07	27.53	*	16.53	*	3.84	.93
6	18.49	*	9.85	.03	11.27	.02	3.14	.95
7	16.45	*	16.22	*	7.57	.06	1.89	.94
8	10.15	.02	18.13	*	9.39	.03	2.41	.95
9	11.70	.03	29.91	*	12.29	.02	4.89	.95
10	15.77	*	20.68	*	6.61	.12	2.72	.88
11	21.44	*	9.17	.05	10.84	.02	3.16	.93
12	10.78	.03	19.61	*	23.58	*	4.06	.97
13	11.75	.01	23.18	*	16.03	*	2.67	.99

*The posterior probability is nil or zero.

a/ The case number corresponds to the province number in the table immediately preceding.

narrower spread. It is from 79.94 percent in group D to 86.16 percent in group C. As a whole the observed variations among groups are significant (table 14).

9.5 Soil composition. The groups of provinces are found to be of dissimilar soil constitution (table 17). Of all the soil series common to all provinces, only the undifferentiated and clay loam types predominate the soils in group A. On the average, clay soils account for a mere 6.41 percent in the same group and less than 5 percent each for the rest.

Five of the seven soil series constitute on the average about 87 percent of the soils in the provinces belonging to group B. In a declining order of magnitude the soil types are clay loam, undifferentiated, sandy loam, clay, and loam. The soil composition of provinces in group C shows the predominance of clay, which averaged over 43 percent. Clay loam and undifferentiated are the two other major soil types with 22.26 and 13.61 percent, respectively. The same three types make up the soil in the provinces in group D. But in the last group the undifferentiated soil series ranks first with 36.71 percent, followed by clay loam with 27.84 percent, and by clay with 14.66 percent.

The test statistics in table 18 show that every pair of groups has statistically significant differences with respect to the given soil types. In all cases the null hypothesis of no difference cannot be accepted at the 1 percent level of significance.

9.6 Rainfall. There is some consistency in the pattern of differences among the groups of provinces based on the normal rainfall over a period of years. Provinces under group A receive less rainfall throughout the year when compared to provinces in groups B and C. The monthly rainfall in the same provinces is also lower than for group D except during January and February (tables 21 and 25). The minimum average rainfall is observed in group D during these two months.

From January to March, the average rainfall is highest in group C. During the same quarter, group B averages more rainfall than group D. In the third quarter, groups B and C record higher average rainfall than does group D, but the latter registers the maximum average during the last quarter.

10.0 Other Implications for Development Planning

Delimitation of homogeneous agricultural regions is fundamental to capacity building in the agricultural sector. A characterization of regions is essential to identify needs and orient research activities towards the evolution of technologies adaptable to the economic and physical setting of various regions.

The regions narrow the starting point of intensive studies. By examining individual profiles (tables 4, 8, 12, 16, 20, 24, 28), it is possible to select core provinces for comparative analysis. In effect, the delineated regions serve as a sampling frame in designing a balance between extensive and intensive research. It is then a simple step to operationally define the geographic bounds over which the results of intensive studies could be related without the need to duplicate the studies in each and every province.

Similarly, the agroclimatic classification is useful to experimentation, e.g., in field trials of varietal performance in different environments. The regional scheme is useful (1) to know the range of environment for which adaptable varieties should be developed, (2) to ensure that tests cover the whole range of distinct environment, (3) to eliminate unnecessary duplication and reduce the cost of experimentation, and (4) to draw some conclusions

Table 17.- Soil composition of the various provincial groupings

	GROUP AVERAGE			
	A	B	C	D
1. Sandy loam	3.61	17.40	1.80	2.36
2. Clay	6.41	14.92	43.09	14.66
3. Undifferentiated	14.88	20.84	13.61	36.71
4. Clay loam	16.01	22.20	22.26	27.84
5. Loam	2.48	12.04	6.85	6.91
6. Sand	0.83	1.16	2.62	1.34
7. Silt loam	4.35	5.18	3.63	5.24

Table 18.- Matrix of F statistics for the hypothesis of no difference between a pair of vectors of group means for the different soil series

	Group A	Group B	Group C
Group B	25.51*		
Group C	42.79*	12.96*	
Group D	25.78*	11.75*	11.56*

*Significant at 1% level; the critical F value at 7 and 33 degrees of freedom is less than 3.474 at 1% level.

Table 19.- Distribution of provinces among the groupings based on soil composition

Group A	Group B	Group C	Group D
1. Antique	1. Albay	1. Bataan	1. Abra
2. Catanduanes	2. Davao	2. Batangas	2. Agusan
3. Cotabato	3. Isabela	3. Bohol	3. Bulacan
4. Occidental Mindoro	4. Pangasinan	4. Bukidnon	4. Cagayan
5. Oriental Mindoro	5. Sorsogon	5. Camarines Norte	5. Capiz
6. Palawan		6. Camarines Sur	6. Ilocos Norte
7. Tarlac		7. Cebu	7. Ilocos Sur
		8. Iloilo	8. Misamis Occidental
		9. Laguna	9. Negros Oriental
		10. La Union	10. Nueva Ecija
		11. Leyte	11. Nueva Viscaya
		12. Marinduque	12. Quezon
		13. Masbate	13. Samar
		14. Misamis Oriental	14. Zamboanga Norte
		15. Negros Occidental	
		16. Pampanga	
		17. Zambales	

Table 20.- Individual profile of provinces in relation to the soil groups

Case # a/	Group A D²	Group A p	Group B D²	Group B p	Group C D²	Group C p	Group D D²	Group D p
	Square of Distance (D^2) from and Posterior Probability (p) for							
	Group A		Group B		Group C		Group D	
	D^2	p	D^2	p	D^2	p	D^2	p
Group A								
1	5.76	1.00	47.96	*	54.16	*	32.09	*
2	8.41	1.00	122.29	*	114.10	*	78.05	*
3	8.85	1.00	56.83	*	40.39	*	24.50	*
4b/	4.71	1.00	98.23	*	106.12	*	76.90	*
5b/	4.71	1.00	98.23	*	106.12	*	76.90	*
6	4.23	1.00	91.84	*	76.38	*	58.51	*
7	11.14	.99	38.88	*	50.05	*	20.70	*
Group B								
1	65.38	*	2.76	1.00	29.30	*	30.73	*
2	117.51	*	10.80	1.00	69.06	*	66.84	*
3	61.05	*	7.34	1.00	22.58	*	18.76	*
4	69.78	*	8.42	.98	19.95	*	17.03	.02
5	83.36	*	6.01	1.00	33.19	*	33.95	*
Group C								
1	88.44	*	40.63	*	5.97	1.00	17.55	*
2	91.33	*	38.18	*	14.17	1.00	34.87	*
3	66.09	*	41.36	*	4.29	1.00	22.36	*
4	66.25	*	35.25	*	4.77	.70	6.47	.30
5	104.48	*	48.89	*	6.31	1.00	32.99	*
6	72.98	*	15.16	*	4.56	.96	11.36	.04
7	87.39	*	39.66	*	2.66	1.00	20.80	*
8	78.18	*	26.20	*	7.15	.99	16.56	.01
9	68.01	*	33.24	*	6.89	.93	12.20	.07
10	75.84	*	35.56	*	3.63	.98	11.66	.02
11	64.80	*	37.47	*	4.79	1.00	15.54	*
12	63.95	*	25.39	*	6.96	.83	10.14	.17
13	98.69	*	33.95	*	13.84	1.00	45.26	*
14	73.94	*	34.29	*	2.15	.97	9.15	.03
15	58.65	*	28.49	*	2.30	.98	9.99	.02
16	97.53	*	57.44	*	28.18	1.00	43.64	*
17	83.74	*	27.15	*	7.96	.99	17.73	.01
Group D								
1	61.15	*	32.06	*	11.13	.04	4.62	.96
2	41.07	*	27.24	*	24.30	*	3.45	1.00
3	42.01	*	35.61	*	16.73	*	3.29	1.00

(continued)

Table 20 (continued)

Case # a/	Square of Distance (D^2) from and Posterior Probability (p) for							
	Group A		Group B		Group C		Group D	
	D^2	p	D^2	p	D^2	p	D^2	p
Group D								
4	34.76	*	28.29	*	31.84	*	5.59	1.00
5	54.42	*	32.32	*	8.77	.06	3.46	.94
6	58.35	*	30.54	*	13.38	.01	3.20	.99
7	63.73	*	36.60	*	17.62	*	6.76	1.00
8	52.46	*	35.69	*	15.18	*	2.89	1.00
9	45.90	*	30.90	*	17.02	*	2.82	1.00
10	60.93	*	28.62	*	25.48	.01	15.37	.99
11	50.86	*	35.37	*	24.46	*	3.06	1.00
12	30.10	*	18.64	*	13.70	.01	4.38	.99
13	57.76	*	32.28	*	7.85	.10	3.41	.90
14	49.50	*	28.67	*	10.18	.01	1.02	.99

*The posterior probability is nil or zero.

a/The case number corresponds to the province number in the table immediately preceding.

b/The soil data refer to the whole Mindoro. The use of a common set of information explains the identical profiles of Occidental and Oriental Mindoro.

Table 21.- Average monthly rainfall pattern of provincial groupings during the first semester

	GROUP AVERAGE			
	A	B	C	D
	(millimeters of rain)			
1. January	76.63	145.56	287.74	39.88
2. February	42.80	69.64	191.40	18.44
3. March	38.56	87.40	137.46	39.44
4. April	33.52	74.06	84.60	57.36
5. May	114.85	168.07	160.42	206.17
6. June	166.57	350.36	197.78	331.28

Table 22.- Matrix of F statistics for the hypothesis of no difference between a pair of vectors of group means for the first semester rainfall

	Group A	Group B	Group C
Group B	37.86*		
Group C	24.26*	54.48*	
Group D	11.61*	13.32*	39.62*

*Significant at 1% level; the critical F value at 6 and 36 degrees of freedom is less than 3.474 at 1% level.

Table 23.- Distribution of provinces among the different rainfall groups, first semester

Group A	Group B	Group C	Group D
1. Agusan	1. Albay	1. Laguna	1. Abra
2. Aklan	2. Bulacan	2. Leyte	2. Bataan
3. Antique	3. Camarines Norte	3. Quezon	3. Batangas
4. Bohol	4. Camarines Sur	4. Samar	4. Marinduque
5. Bukidnon	5. Cavite	5. Sorsogon	5. Nueva Viscaya
6. Cagayan	6. Ilocos Norte		6. Occidental Mindoro
7. Capiz	7. Ilocos Sur		7. Oriental Mindoro
8. Catanduanes	8. Pangasinan		8. Pampanga
9. Cebu			9. Romblon
10. Iloilo			10. Tarlac
11. Isabela			11. Zambales
12. Lanao			
13. La Union			
14. Masbate			
15. Misamis Occidental			
16. Misamis Oriental			
17. Negros Occidental			
18. Negros Oriental			
19. Nueva Ecija			
20. Palawan			
21. Surigao			

Table 24.- Individual profile of provinces in relation to the groups based on first semester rainfall

Case # a/	Group A D^2	Group A p	Group B D^2	Group B p	Group C D^2	Group C p	Group D D^2	Group D p
Group A								
1	3.53	1.00	55.23	*	34.68	*	22.14	*
2	4.56	1.00	54.79	*	45.09	*	17.18	*
3	4.70	1.00	55.66	*	44.82	*	17.66	*
4	2.58	1.00	46.79	*	31.04	*	14.56	*
5	2.94	1.00	56.40	*	52.48	*	17.17	*
6	2.18	1.00	39.71	*	31.91	*	14.16	*
7	4.65	1.00	55.20	*	45.04	*	17.45	*
8	6.95	1.00	56.52	*	24.63	*	20.03	*
9	3.62	.89	25.35	*	50.34	*	7.82	.11
10	1.53	.89	35.77	*	54.79	*	5.71	.11
11	2.14	.92	32.83	*	47.31	*	7.03	.08
12	3.66	1.00	48.32	*	61.52	*	14.48	*
13	3.58	.97	46.15	*	42.34	*	10.28	.03
14	6.87	1.00	67.20	*	38.37	*	27.67	*
15	3.66	1.00	48.32	*	61.52	*	14.48	*
16	3.58	1.00	55.78	*	53.85	*	18.63	*
17	6.87	.89	35.77	*	54.79	*	5.71	.11
18	3.66	1.00	67.91	*	24.82	*	25.80	*
19	4.11	.65	41.56	*	56.90	*	5.32	.35
20	2.73	.66	31.96	*	54.46	*	4.09	.34
21	3.61	1.00	61.23	*	32.14	*	24.07	*
Group B								
1	44.42	*	4.13	1.00	111.05	*	24.19	*
2	59.86	*	4.81	1.00	142.98	*	27.30	*
3	43.87	*	5.35	1.00	100.34	*	24.62	*
4	43.71	*	4.35	1.00	105.26	*	24.00	*
5	93.08	*	19.73	1.00	192.77	*	52.29	*
6	39.48	*	5.68	1.00	111.31	*	21.54	*
7	45.97	*	2.89	1.00	124.49	*	23.06	*
8	42.54	*	8.73	.97	135.47	*	15.87	.03
Group C								
1	27.46	*	105.67	*	4.25	1.00	62.26	*
2	49.74	*	132.62	*	2.05	1.00	89.13	*
3	50.24	*	149.09	*	5.01	1.00	92.06	*

Square of Distance (D^2) from and Posterior Probability (p) for each group.

(continued)

Table 24 (continued)

Case # a/	Square of Distance (D^2) from and Posterior Probability (p) for							
	Group A		Group B		Group C		Group D	
	D^2	p	D^2	p	D^2	p	D^2	p
Group C								
4	46.99	*	86.26	*	14.72	1.00	71.05	*
5	75.54	*	176.02	*	18.64	1.00	123.94	*
Group D								
1	35.29	*	62.15	*	102.71	*	18.59	1.00
2	19.05	*	10.19	.03	87.09	*	3.35	.97
3	5.29	.18	23.40	*	68.29	*	2.22	.82
4	21.30	*	22.43	*	89.28	*	4.67	1.00
5	27.30	*	37.18	*	119.76	*	9.50	1.00
6	7.29	.09	28.48	*	79.31	*	2.67	.91
7	8.09	.04	23.08	*	75.70	*	1.50	.96
8	19.05	*	10.19	.03	87.09	*	3.35	.97
9	13.96	.03	18.05	*	88.50	*	7.12	.97
10	8.33	.03	22.64	*	68.72	*	1.09	.97
11	20.97	.01	23.37	*	64.89	*	10.99	.99

*The posterior probability is nil or zero.

a/ The case number corresponds to the province number in the table immediately preceding.

Table 25.- Average monthly rainfall pattern of provincial groupings during the second semester

	GROUP AVERAGE			
	A	B	C	D
	(millimeters of rain)			
1. July	176.18	389.90	408.63	287.44
2. August	152.46	428.93	410.61	294.59
3. September	141.45	388.40	274.30	266.82
4. October	171.41	242.07	222.27	245.28
5. November	139.17	225.67	258.66	303.01
6. December	81.08	189.97	173.21	235.80

Table 26.- Matrix of F statistics for the hypothesis of no difference between a pair of vectors of group means for the second semester rainfall

	Group A	Group B	Group C
Group B	18.82*		
Group C	20.40*	23.21*	
Group D	12.70*	9.25*	5.49*

*Significant at 1% level; the critical F value at 6 and 36 degrees of freedom is less than 3.474 at 1% level.

Table 27.- Distribution of provinces among the different rainfall groups, second semester

Group A	Group B	Group C	Group D
1. Agusan	1. Abra	1. Batangas	1. Albay
2. Aklan	2. Camarines Norte	2. Bulacan	2. Bataan
3. Antique	3. Camarines Sur	3. Cagayan	3. Catanduanes
4. Bohol	4. Cavite	4. La Union	4. Isabela
5. Bukidnon	5. Ilocos Norte	5. Marinduque	5. Laguna
6. Capiz	6. Ilocos Sur	6. Samar	6. Leyte
7. Cebu	7. Nueva Ecija	7. Zambales	7. Masbate
8. Iloilo	8. Pangasinan		8. Nueva Viscaya
9. Lanao	9. Quezon		9. Palawan
10. Misamis Occidental	10. Tarlac		10. Pampanga
11. Misamis Oriental			11. Sorsogon
12. Negros Occidental			
13. Negros Oriental			
14. Occidental Mindoro			
15. Oriental Mindoro			
16. Romblon			
17. Surigao			

Table 28.- Individual profile of provinces in relation to the groups based on second semester rainfall

Case # a/	Square of Distance (D^2) from and Posterior Probability (p) for							
	Group A		Group B		Group C		Group D	
	D^2	p	D^2	p	D^2	p	D^2	p
Group A								
1	3.25	1.00	26.86	*	33.30	*	17.76	*
2	4.20	1.00	23.64	*	38.78	*	20.85	*
3	4.39	1.00	23.78	*	39.84	*	21.50	*
4	.23	1.00	21.69	*	25.24	*	11.65	*
5	3.20	1.00	25.36	*	41.29	*	21.20	*
6	4.29	1.00	23.78	*	39.16	*	21.11	*
7	.56	.99	21.69	*	21.37	*	10.03	.01
8	3.63	.80	21.42	*	13.20	.01	6.51	.19
9	3.11	1.00	28.58	*	34.15	*	18.79	*
10	3.11	1.00	28.57	*	34.22	*	18.83	*
11	3.28	1.00	26.70	*	39.01	*	20.50	*
12	3.63	.80	21.42	*	13.21	.01	6.51	.19
13	.43	1.00	22.22	*	29.63	*	13.80	*
14	11.26	.99	19.95	.01	59.02	*	31.96	*
15	1.73	.90	15.12	*	19.75	*	6.11	.10
16	4.08	.99	27.38	*	20.49	*	13.37	.01
17	3.25	1.00	26.78	*	33.95	*	18.09	*
Group B								
1	21.09	*	4.38	.99	32.61	*	13.02	.01
2	41.56	*	10.96	1.00	64.47	*	29.54	*
3	22.25	*	6.65	.73	28.94	*	8.60	.27
4	26.49	*	2.91	1.00	57.70	*	22.16	*
5	32.47	*	4.42	1.00	42.74	*	18.28	*
6	70.81	*	19.22	1.00	96.21	*	54.21	*
7	12.58	.01	2.80	.99	41.36	*	13.75	*
8	21.88	*	2.50	1.00	34.10	*	13.09	*
9	8.24	.18	6.05	.56	29.52	*	7.57	.26
10	11.02	.02	4.21	.53	21.65	*	4.52	.45
Group C								
1	12.74	.03	36.27	*	5.82	.84	9.46	.13
2	50.02	*	52.19	*	6.15	1.00	20.50	*
3	24.78	*	30.77	*	4.71	.58	5.38	.42
4	30.30	*	36.73	*	5.25	.98	13.41	.02
5	35.61	*	48.60	*	5.68	.98	13.37	.02

(continued)

Table 28 (continued)

Case # a/	Square of Distance (D^2) from and Posterior Probability (p) for							
	Group A		Group B		Group C		Group D	
	D^2	p	D^2	p	D^2	p	D^2	p
Group C								
6	33.78	*	40.32	*	4.30	.96	10.74	.04
7	69.09	*	84.26	*	27.59	1.00	48.04	*
Group D								
1	18.64	*	18.02	*	9.11	.05	3.36	.95
2	16.74	*	12.93	*	9.19	.04	2.56	.96
3	15.89	.01	15.86	.01	17.57	*	6.98	.97
4	20.46	.02	24.37	*	27.16	*	12.48	.98
5	57.44	*	33.15	*	24.18	.03	17.09	.97
6	11.53	.02	27.01	*	6.91	.20	4.20	.78
7	8.92	.03	11.48	.01	14.66	*	1.71	.96
8	15.07	*	15.02	.01	13.91	.01	4.70	.98
9	7.70	.11	12.87	.01	13.22	.01	3.64	.87
10	16.74	*	12.93	*	9.19	.04	2.56	.96
11	18.62	*	13.85	.02	16.18	*	5.52	.98

*The posterior probability is nil or zero.

a/ The case number corresponds to the province number in the table immediately preceding.

as to what is suited to which areas. Along this line, there are benefits from a regional classification of an international dimension since there may be several similar areas in different countries.

The characteristics of provincial groups present some guidance in the search for constraints to agricultural productivity. Integration of growth and regional income distribution goals in agricultural development necessitates eliminating specific factors which inhibit transfers of technical efficiency. Without conscious efforts to deal with such restraints, continued imbalance in regional growth is likely to accentuate disparities in income. Further, the inability to generate widespread distribution of productivity gains throughout the economy has been closely associated with agricultural stagnation and with the failure to utilize growth as a vehicle of viable and dynamic process of sustained development (M. E. Abel and K. W. Easter, 1971).

Constraints and potentials determine which development activities are feasible and what can be undertaken in what regions. Let us take the land resource categories (table 5). Why is there no positive relationship between irrigation and effective cropping index? In fact, the characteristics of groups A and D suggest a negative association. Recall that the census data relate to the period before the development of modern rice, the photoperiod-insensitive, nonseasonal, short-maturing variety. More double cropping in group A than in group D can be explained by the differences in rice culture rather than irrigation. Provinces in group A grew more upland and rainfed rice. Those in group D, mostly in the Central Plains of the Philippines, cultivate lowland rice. But compare the traditional lowland and upland rice varieties. From sowing, _Binato_, an upland variety, flowers in 62 days if day length is 8 hours, 95 days if it is 16 hours. In contrast, Intan, a lowland variety, takes 80 days from sowing to flowering for 8-hour day lengths and 149 days for 16-hour day lengths. At that time, the constraint to greater production in group D was not irrigation but the lack of a lowland rice which could be grown fast enough any time of the year to permit double cropping. The example also illustrates the temporal sequence of constraints, that is, how other inputs become more crucial as a major constraint is eliminated. Clearly, there would not have been much gain from a credit program in group D during the early 1960's. The progress in rice breeding has completely altered the situation during the 1970's.

11.0 Distribution of Provinces

With respect to the final distribution of provinces, there was no clear correspondence between the productivity groups and those of other agroclimatic variables. The provinces with similar rice yields over the years are not precisely the same units which made up homogeneous regions based on other criteria. This should not be construed to imply an absence of a relationship between rice productivity, on the one hand, and regional attributes on the other. On the contrary, a perfect correspondence in the provincial distribution from one set of criteria to another would have looked fortuitous.

The correlation between regional characteristics and geographic rice yields is not obvious from a visual inspection of the group profiles. Not only is there too much information to absorb, but the absence of any definite productivity ranking that remains consistent over the years makes it difficult to see the relationship between productivity and regional characteristics. The changing distribution of provinces implies a complex enough relationship between rice yields and the regional characteristics as to be unrecognizable from an ocular inspection of several tables. It should also be remembered that while the productivity variable has a time dimension, the others have not. In most cases, the single year, for which the variables were measured, varies. It is plausible to assert that the group membership for any delineation not based on permanent attributes can change over time.

12.0 Mapping Regional Variations in Rice Yield

To explain and sort out the regional effects on productivity, we regress the rice yields of individual provinces on agroclimatic characteristics. We employed the results of discriminant analysis to create dummy variables for the agroclimatic regions. At the provincial level, what we were able to estimate is an incompletely specified version of equation (1). For lack of information, the X variables are omitted. Our estimating equation, in the strict sense, is not a production function but we regard it only as a scheme for mapping the provincial rice yields among the agroclimatic regions.[8/]

Table 29 summarizes the regression results. In this table are the coefficients and related statistics of a general relationship. It postulates that all the agroclimatic variables relate significantly to rice yields, so that the first regression includes all group and time dummies.

The regression constant is the average of the rice yields in 1970 for the provinces which belong to group D of every classification. The other coefficients measure the deviation in rice productivity between a given group and group D. At the same time, the coefficients are also estimates of how much of the overall yield gaps could be accounted for by the set of

[8/] Had the model included all possible interaction terms, the analysis would have been equivalent to an analysis of variance to test the differences in the means of composite agroclimatic groups.

Table 29.- Coefficients and related statistics of a regression of provincial rice yields on agroclimatic variables

	Regression Coefficients	"t" Values
Land Resource		
D_{11} - group A	- 7.91	-1.927
D_{21} - group B	-10.67**	-3.191
D_{31} - group C	-12.59**	-3.757
Agricultural Infrastructures		
D_{12} - group A	- 0.84	-0.318
D_{22} - group B	- 1.54	-0.357
D_{32} - group C	- 0.76	-0.312
Population Characteristics		
D_{13} - group A	-13.28**	-4.686
D_{23} - group B	- 7.82**	-2.679
D_{33} - group C	19.10**	-4.397
Soil Composition		
D_{14} - group A	- 1.88	-0.561
D_{24} - group B	5.36	1.674
D_{34} - group C	9.35**	4.002
Rainfall, First Semester		
D_{15} - group A	7.40	1.673
D_{25} - group B	6.21	1.831
D_{35} - group C	4.82	1.429
Rainfall, Second Semester		
D_{16} - group A	- 2.41	-0.659
D_{26} - group B	0.68	0.197
D_{36} - group C	13.24**	3.148
Year Dummies		
D_1 - 1971	- 0.52	-0.232
D_2 - 1972	9.88**	3.830
D_3 - 1973	8.29**	3.215
D_4 - 1974	17.76**	6.885
Constant Term	65.23**	14.804
Residual Sum of Squares		20483.1505
Coefficient of Determination		0.4552
Adjusted Coefficient of Determination		0.3889
F Statistics for Significance of Regression (22, 181)		6.8743**

**Significant at 1% level; the critical "t" value for a two tailed test at 1% level of significance is 2.576 and the critical F value at 22 and 181 degrees of freedom is less than 2.336 at 1% level of significance.

agroclimatic variables. Let us pick a province, for example, one which is classified in group A with respect to all the agroclimatic variables. From table 29, it can be shown that our example has a lower yield when compared with the base province. The estimated total difference is -26.32 cavans per hectare. Of this, -7.91 can be attributed to land resource, -13.28 to population characteristics, 7.40 to first semester rainfall, etc. A similar accounting of the yield gaps can be made for any of the possible combinations of groups by examining the appropriate coefficients.

Land resource and population characteristics explain the greater part of the yield differences (table 29). Of course, the coefficients reflect the effect of the excluded variables to the extent that they are correlated with the included ones. Looking back at table 5, the provincial yield gaps can be linked positively with the percentages of rice area and irrigated hectarage but negatively with cropping intensity. To explain this relationship, it is essential to update our information on land resource. From our knowledge of government rice programs, we can say that group D provinces still have the highest percent rice area and effective rice area irrigated. But cropping intensity would have changed significantly with the development of short-maturing, photoperiod insensitive rice. It has probably increased more rapidly in group D provinces relative to the rest. Therefore, it is only normal to expect that rice yield is highest in a group with a major percent of an area planted to rice and with the highest percentage of the rice area irrigated.

The percentage of unpaid family labor would appear to be directly related to rice productivity if we disregard group B in table 13. Working for oneself apparently provides more motivation. As regards group B, remember that it is more urbanized and externalities could have helped rice yields. In urban areas, farms are nearer to the sources of supporting inputs. Further, there are more competing uses for land and the opportunity cost is such that marginal lands are diverted out of rice farming. The same is true for labor. Only those productive in rice farming will plant rice. Furthermore, with more cash incomes and a budget surplus there is the ability to provide for the purchased inputs.

The year effects on rice productivity are also evident (table 29). The inter-year variability can be interpreted as a reflection of factors which change over time. It can be a manifestation of year to year weather variations, implementation of government agricultural programs, and/or temporal changes in the agroclimatic variables themselves. For instance, the year effect of 18.11 cavans in 1974 may for the most part be credited to the Masagana 99 program which was in full operation during the period.

We test the set of hypotheses that all terms, where the standard error exceeds the magnitude of the corresponding coefficient, are simultaneously insignificant. With these restrictions imposed on the model, a constrained equation was estimated. The results are reported in table 30.

The F-statistics for the set of null hypotheses are

$$F = \frac{(20581.4466 - 20483.1505)/7}{(20483.1505)/(204 - 23)} = 0.7513 .$$

For a 1 percent level of significance, the critical F-value at 7 and 181 degrees of freedom is about 2.79. Since the computed F is much less than 2.79, there would be no reason to reject the hypotheses. The seven coefficients tested are not statistically different from zero. It appears from the test that agricultural infrastructure and first semester rainfall are altogether insignificant. The insignificance could have arisen out of multicollinearity problems and exclusion bias. However, assuming that the test is valid and the coefficients are indeed insignificant, the results are not conclusive that agricultural infrastructures are unimportant determinants of geographic productivity.

The agricultural infrastructure influences market efficiency. It directly affects farm input usage because of its impact on the prices of inputs, as well as output. Therefore, the test results are consistent with points A and B in figure 1. It is not uncommon for rice farmers to grow the new varieties under traditional cultural practices and lower input use. In such instances, land productivity may not have improved but there is certainly a greater gain in the efficiency of using variable inputs. In other words, our results are not inconsistent with the existence of constraints to the economic and physical availability of inputs. From a methodological point of view, the results provide some evidence of the limitations of merely comparing regional productivity based on partial measures. The model is inadequate and can lead to misleading inferences.

13.0 Conclusions

This paper has illustrated an operational scheme to define distinct agroclimatic regions which are internally homogeneous with respect to several criteria. For us the agroclimatic classification is part of a broader methodology and is only an intermediate product which we will later use in identifying the structure of rice productivity. However, we have also indicated the relevance of the agroclimatic scheme and how it may be utilized in development planning.

The distribution of provinces among the rice productivity groups did not match those based on other agroclimatic variables because of the complexity of the relationship. There was no discernible yield hierarchy among the groups.

Table 30.- Regression coefficients and other statistics for the constrained regression of provincial rice yields on agroclimatic characteristics

	Regression Coefficients	"t" Values
Land Resource		
D_{11} - group A	- 7.88*	-2.011
D_{21} - group B	- 9.02**	-3.899
D_{31} - group C	-11.17**	-4.381
Population Characteristics		
D_{13} - group A	-12.81**	-5.211
D_{23} - group B	- 7.31**	-3.026
D_{33} - group C	-17.76**	-4.860
Soil Composition		
D_{24} - group B	5.80*	2.059
D_{34} - group C	9.06**	5.048
Rainfall, First Semester		
D_{15} - group A	4.90*	2.025
D_{25} - group B	6.23*	2.302
D_{35} - group C	4.55	1.583
Rainfall, Second Semester		
D_{36} - group C	12.67**	3.943
Year Dummies		
D_2 - 1972	10.22**	4.936
D_3 - 1973	8.64**	4.169
D_4 - 1974	18.11**	8.740
Constant Term	62.66**	23.508

Residual Sum of Squares	20581.4466
Coefficient of Determination	0.4526
Adjusted Coefficient of Determination	0.4089
F Statistics for Significance of Regression (15, 188)	10.3623**

*Significant at 5% level; the critical "t" value for a two tailed test at 5% level of significance is 1.960.

**Significant at 1% level; the critical "t" value for a two tailed test at 1% level of significance is 2.576 and the critical F value at 15 and 188 degrees of freedom is less than 2.336 at 1% level of significance.

We demonstrated the use of our agroclimatic classification in a regression to map provincial rice yields. In the context of our regression results, the inter-year variability in land productivity is quite substantial. The yearly changes overshadow the regional gaps in productivity. Separating the time or year effects discloses strong regional variations in productivity. The evidence is ample that the characteristics of the agroclimatic regions have a significant impact on such variations.

To compare rice productivity of provinces is inadequate in judging the importance of individual agroclimatic variables. The inadequacy results not from a desire to oversimplify the model but from a lack of information at the provincial level. The development and updating of information at the provincial and lower levels is indispensable to development planning and certainly has great social returns.

APPENDIX A

Discriminant Model

Climate, rainfall, soils, topography, and water control are a few of the variables utilized for agroclimatic zoning. Handling more than three variables for classification can be operationally complicated. The options are using subjective judgments, objective statistical techniques, or both, depending upon a researcher's expert knowledge of study areas and the availability of quantitative measurements.

Principal component is a technique widely employed in the literature to reduce the dimension of the analysis. The technique has been applied to construct composite indexes of homogeneity and to stratify regions (E. C. Rhodes, 1937; M. G. Kendall, 1939; M. J. Hagood, et al., 1941; M. J. Hagood, 1943; M. J. Hagood and E. H. Bernert, 1945). Since the 1960's the advent of high speed computers has given impetus to their use in quantitative geography and later in studying patterns of economic development (B. J. L. Berry, 1960; 1961a; 1961b; F. V. Waugh, 1962; B. J. L. Berry, 1965; D. M. Smith, 1968; J. G. M. Hilhorst, 1971; F. Suzuki, not dated). Integration of hierarchical grouping analysis with earlier procedures lent refinements and more precision to regional delineation (J. H. Ward, Jr., 1963; B. J. L. Berry, 1967; N. A. Spence, 1968).

The principal component technique is not without shortcomings. Estimates of factor loadings are susceptible to biases. The naming of hypothetical factors and their interpretation are not always simple. And there exists the possibility that observations may have identical indexes (and thus end up in the same group) even if they possess contrasting characteristics. Theoretically, these problems can be overcome (H. H. Harman, 1967).

There are some practical difficulties with the principal component method. There are a number of alternative estimation procedures and which one to use is not, in view of our present objectives, intuitive. Discriminant analysis, a procedure for finding a set of discriminant functions which best separate groups, is more appealing and practical. Discriminant scores are used to group observations and to classify new ones.

Given a set of observations from a number of distinct groups, each of which is characterized by p measurements with multivariate normal probability density, the likelihood ratio L for any pair of groups i and j is:

$$L = \frac{K \exp\,[-1/2(Z-M_i)'V^{-1}(Z-M_i)]}{K \exp\,[-1/2(Z-M_j)'V^{-1}(Z-M_j)]} \qquad (1)$$

where:

V is a p x p matrix of dispersion common to all groups

Z is a p x 1 vector of attributes

$Z-M_i$ is a p x 1 vector of deviations of Z from the ith group mean and M_i is a p x 1 vector of means

K is a constant

Simplifying (1) further gives:

$$L = \exp\,[-1/2(Z-M_i)'V^{-1}(Z-M_i) + 1/2(Z-M_j)'V^{-1}(Z-M_j)]$$

$$L = \exp\,[-1/2Z'V^{-1}Z + 1/2M_i'V^{-1}Z + 1/2Z'V^{-1}M_i - 1/2M_i'V^{-1}M_i$$

$$+ 1/2Z'V^{-1}Z - 1/2M_j'V^{-1}Z - 1/2Z'V^{-1}M_j + 1/2M_j'V^{-1}M_j]$$

$$L = \exp\ [Z'V^{-1}(M_i - M_j) - 1/2(M_i + M_j)'V^{-1}(M_i - M_j)]$$

$$\ln L = Z'V^{-1}(M_i - M_j) - 1/2(M_i + M_j)'V^{-1}(M_i - M_j)$$

$$\ln L = Z'D - 1/2(M_i + M_j)'D \tag{2}$$

where:

$$D = V^{-1}(M_i - M_j) \tag{3}$$

is a $p \times 1$ vector of discriminant function coefficients. It can be shown that D is a vector such that the linear combination Z'D maximizes the ratio of between to within group variances or sum of squares (C. R. Rao, 1952; T. W. Anderson, 1958; W. W. Cooley and P. R. Lohnes, 1962; I. Adelman and C. T. Morris, 1968). In other words, Z'D is the linear discriminant function which best separates the _i_th from the _j_th group.

The discriminant function in (2) can alternatively be defined in terms of the parameters of the _i_th group only. In such cases the function is derived from the likelihood function of the _i_th group rather than from a likelihood ratio (C.R. Rao, 1952). Thus:

$$f_i = K \exp\ [-1/2(Z - M_i)'V^{-1}(Z - M_i)]$$

$$\ln f_i = K' - 1/2(Z - M_i)'V^{-1}(Z - M_i)$$

$$\ln f_i = K' - 1/2Z'V^{-1}Z + Z'V^{-1}M_i - 1/2M_i'V^{-1}M_i$$

$$Z'V^{-1}M_i - 1/2M_i'V^{-1}M_i = K''$$

$$Z'D - 1/2M_i'D = K'' \tag{4}$$

where:

$$D = V^{-1}M_i \tag{5}$$

K, K', K'' are some constants.

Classifying provinces on the basis of p characters into, say, four groups is the same as dividing the p dimensional space into four regions R_1, R_2, R_3, and R_4. The expected value of the proportion of wrong classification is minimum for a decision rule such that:

R_1 is defined by $f_1 \geq f_2$, $f_1 \geq f_3$, $f_1 \geq f_4$

R_2 is defined by $f_2 \geq f_1$, $f_2 \geq f_3$, $f_2 \geq f_4$

R_3 is defined by $f_3 \geq f_1$, $f_3 \geq f_2$, $f_3 \geq f_4$

R_4 is defined by $f_4 \geq f_1$, $f_4 \geq f_2$, $f_4 \geq f_3$

assuming that every province is equally likely to be drawn from any group (C. R. Rao, 1952; T. W. Anderson, 1958). The rule is a maximum likelihood rule since a province is assigned to the group for which its likelihood or discriminant score is highest.

Comparative Interregional Productivity

Assume that n sets of variables are used for defining regions and that m homogeneous groups are delineated for each set. Assume also that the provincial yield data cover a period of T years. Then, the model takes the form:

$$Y_{kt} = \sum_{i=1}^{m} \sum_{j=1}^{n} \beta'_{ij} D_{ijk} + \sum_{t-1}^{T} \Gamma'_t D_t + e_{kt} \qquad (6)$$

where:

Y_{kt} is rice yield of kth province in time t

D_{ijk} = 1 if kth province belongs to ith group of a given jth set; and = 0, otherwise

D_t is also a binary variable for year effects

Depending on the nature of the error term e_{kt}, an appropriate estimation procedure can be devised to obtain efficient and unbiased estimators of β'_{ij} and Γ'_t. We shall assume the error term to possess such characteristics as to make ordinary least-squares estimators unbiased and efficient. That suggests an error term with a finite and constant variance for all $\underline{t}$'s. In addition, provincial rice yield Y_{kt}, presumably an average figure, is assumed to have a common denominator for all $\underline{k}$.

Note that (6) provides no interaction effects among $\underline{n}$ sets of variables. The model is completely additive. The difference in rice yields between any two groups in set $\underline{j}$ remains constant over all $\underline{i}$'s of other sets. An additive model seems justified on two counts. There is no prior reason to expect significant interactive influence on rice yields from the sets of variables. Also, adding interaction terms greatly reduces the degrees of freedom from a limited number of observations.

It is not difficult to see that (6) can not be estimated. Since

$$\sum_{i=1}^{m} D_{ij} = 1 \text{ for all } \underline{j} \text{ and } \sum_{t=1}^{T} D_t = 1,$$

there is perfect collinearity. We modify (6) by eliminating D_{mj} for all $\underline{j}$'s as well as D_T but we incorporate an intercept term as follows:

$$Y_{kt} = \alpha + \sum_{i=1}^{m-1} \sum_{j=1}^{n} (\beta'_{ij} - \beta'_{mj})D_{ij} + \sum_{t=1}^{T-1} (\Gamma'_t - \Gamma'_T)D_t + e_{kt} \qquad (7)$$

which is equivalent to:

$$Y_{kt} = \alpha + \sum_{i=1}^{m-1} \sum_{j=1}^{n} \beta_{ij} D_{ij} + \sum_{t=1}^{T-1} \Gamma_t D_t + e_{kt} \qquad (7')$$

It is obvious from (7) that a test of significance of β_{ij} is actually equivalent to a test of significance of a difference in rice yields between group m and group i. Other forms of (6) may be specified and estimated but (7') has the convenience of a direct test of our hypothesis.

The test procedure for significance of individual coefficients is a t-test. The test statistic can be computed as:

$$\hat{t} = \frac{(\hat{\beta}_{ij} - \text{constant})}{\text{S.E. } (\hat{\beta}_{ij})}$$

$$i = 1, 2, \ldots, m-1$$

$$j = 1, 2, \ldots, n$$

For our null hypothesis:

$$H_o: \ \beta_{ij} = 0$$

the test statistic is simply the ratio of $\hat{\beta}_{ij}$ to its standard error (S.E.).

To test the significance of a subset of coefficients, we utilize the F-statistic. Equation (7') is estimated as:

$$Y_{kt} = \hat{\alpha} + \sum_{i=1}^{m-1} \sum_{j=1}^{n} \hat{\beta}_{ij} D_{ij} + \sum_{t=1}^{T-1} \hat{\Gamma}_t D_t + \hat{e}_{kt} \qquad (8)$$

The set of simultaneous hypotheses, e.g.,

$$H_o: \ \beta_{1j} = \beta_{2j} = \ . \ . \ . = \beta_{rj} = 0$$

can be imposed on (7'). It results in a constrained regression such as:

$$Y_{kt} = \hat{\alpha}^* + \sum_{i=r+1}^{m-1} \sum_{j=1}^{n} \hat{\beta}^*_{ij} D_{ij} + \sum_{t=1}^{T-1} \hat{\Gamma}^*_t D_t + \hat{v}_{kt} \qquad (9)$$

An F-statistic is formed as:

$$F = \frac{\left(\sum_{k=1}^{K} \sum_{t=1}^{T} \hat{v}_{kt}^2 - \sum_{k=1}^{K} \sum_{t=1}^{T} \hat{e}_{kt}^2\right) / (r), \text{ number of restrictions}}{\sum_{k=1}^{K} \sum_{t=1}^{T} \hat{e}_{kt}^2 \ / \ (KT - [(m-1)(n) + (T-1)] - 1)}$$

APPENDIX B

The coefficients for classification are presented in appendix table B1. There are seven sets of four discriminant functions, one for each set of agroclimatic criteria. Every set of four discriminant functions is used independently of other sets. There is one discriminant function for each group in every set. For example, for set I, Rice Productivity, the coefficients of the discriminant function for group A appear in the first column, those for group B appear in the second column, etc.

The coefficients in appendix table B1 may be used to classify new observations into the groupings in this paper provided the new observations have the same data relating to all variables in the agroclimatic set within which a classification is to be made. Let us illustrate. Assume that we have an additional case to classify in the productivity groups and that we have data on rice productivity from 1970 through 1974. We use the following functions:

$$F_A = -71.74 + 2.5116X_1 - 0.0289X_2 + 0.3214X_3 - 0.0047X_4 + 0.2909X_5$$

$$F_B = -108.88 + 3.7932X_1 - 0.0951X_2 + 0.2562X_3 + 0.0887X_4 + 0.0177X_5$$

$$F_C = -140.84 + 4.4145X_1 - 0.0532X_2 + 0.3035X_3 - 0.0622X_4 + 0.0522X_5$$

$$F_D = -174.84 + 5.2094X_1 - 0.0994X_2 + 0.3238X_3 - 0.1563X_4 - 0.0662X_5$$

where:

X_1 is 1970 rice productivity

X_2 is 1971 rice productivity

X_3 is 1972 rice productivity

X_4 is 1973 rice productivity, and

X_5 is 1974 rice productivity.

We allocate the new observation to group A if F_A is highest, to group B if F_B is highest, to group C if F_C is highest or to group D if F_D is highest.

The procedure is the same for classifying new observations with respect to the other agroclimatic groups.

Appendix Table B1.- Coefficients of the final discrimination functions for classifying the provinces according to the agroclimatic variables

	Coefficients for Group			
	A	B	C	D
I. Rice Productivity				
1. 1970	2.5116	3.7932	4.4145	5.2094
2. 1971	-.0289	-.0951	-.0532	-.0994
3. 1972	.3214	.2562	.3035	.3238
4. 1973	-.0047	.0887	-.0622	-.1563
5. 1974	.2909	.0177	.0522	-.0662
Constant Term	-71.74	-108.88	-140.84	-174.84
II. Land Resource				
1. Effective cropping index for rice (percent)	6.5679	5.7992	4.8304	5.3660
2. Percent rice area	3.9276	3.4367	2.8730	3.3048
3. Percent of rice area irrigated	-4.1562	-3.5874	-2.9911	-3.3420
4. Percent land graded over 30 degrees	.3710	.3153	.3047	.3758
5. Percent idle land	.6250	.6175	.5578	.5721
Constant Term	-530.67	-415.66	-291.49	-365.49
III. Agricultural Infrastructures				
1. Loans to agriculture (pesos per arable hectare)	.0314	.1033	.0163	.0204
2. Percent of earth road	-.0328	.1783	.2565	.0341
3. Ratio of 1972 to 1960 irrigated rice area	2.0213	.0552	.5927	.7604
4. Rice milling capacity (cavans per day per 10,000 rice hectares)	-.2791	-.1006	.0500	-.0710
5. Warehouse capacity (cavans/rice hectare)	.1752	.0639	-.0247	.0441
6. Road density (kilometers of road per 1,000 arable hectares)	2.0742	1.1318	.2735	.8783
Constant Term	-30.86	-36.82	-9.72	-8.13

(continued)

Appendix Table B1. (continued)

	Coefficients for Group			
	A	B	C	D
IV. Population Characteristics				
1. Percent self-employed	2.0503	-.2621	.0753	-.8893
2. Percent rural population	4.8048	3.4336	3.8301	4.1500
3. Income tax per capita	-7.1162	-5.5826	-6.8054	-6.7553
4. Literacy rate	8.9091	8.1873	9.0584	8.7484
5. Percent family labor	-.5225	-.9420	-1.5868	-.9419
6. Percent of labor force in agriculture	3.2324	3.0820	3.5346	3.2948
7. Annual budget surplus per family (pesos)	-.0055	-.0027	-.0062	-.0077
8. Population density (number of persons per square kilometer)	.1549	.1401	.1328	.1405
Constant Term	-597.03	-498.97	-612.10	-569.73
V. Soils				
1. Sandy loam	1.4682	4.0446	2.6610	2.3873
2. Clay	1.1126	2.3580	2.5870	2.1977
3. Undifferentiated	.9023	1.7450	1.7921	1.7862
4. Clay loam	1.0446	2.0711	2.1326	2.0280
5. Loam	1.1753	2.5865	2.8005	2.3613
6. Sand	2.4968	5.7060	6.3296	4.9326
7. Silt loam	.6958	1.0898	.9221	1.2311
Constant Term	-26.70	-117.04	-115.04	-96.03
VI. Rainfall, First Semester				
1. January	-.0317	.1905	-.2374	.0370
2. February	.1045	-.7069	.9142	-.2875
3. March	.0132	.4443	-.2238	.2479
4. April	-.0517	.4204	-.4081	.1532
5. May	.0264	-.3180	.1816	-.0820
6. June	.0062	.1654	-.0342	.0595
Constant Term	-3.83	-27.87	-33.25	-10.15
VII. Rainfall, Second Semester				
1. July	.0063	-.1144	.1795	.0370
2. August	.0005	.0794	-.0506	.0102
3. September	.0033	.0971	-.0695	.0069

(continued)

Appendix Table B1. (continued)

	Coefficients for Group A	B	C	D
VII. Rainfall, Second Semester				
4. October	.0108	.0073	-.1904	-.0982
5. November	.0038	-.0145	.1947	.1036
6. December	-.0018	.0266	-.0220	-.0054
Constant Term	-3.33	-16.73	-20.25	-12.14

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